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Attached please find the certified copy of the foreign application from which priority is claimed for this case:

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Europe	02258164.9	11/27/2002

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The attached documents are exact copies of the European patent application described on the following page, as originally filed.

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Patentanmeldung Nr. **Patent application No.** **Demande de brevet n°**

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Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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R C van Dijk

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(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Lithographic apparatus and device manufacturing method

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Lithographic Apparatus and Device Manufacturing Method

The present invention relates to a lithographic projection apparatus comprising:

- a radiation system for supplying a pulsed projection beam of radiation;
- programmable patterning means for patterning the projection beam according to a desired pattern;
- a substrate table for holding a substrate; and
- a projection system for projecting the patterned beam onto a target portion of the substrate.

The term "programmable patterning means" as here employed should be broadly interpreted as referring to means that can be used to endow an incoming radiation beam with a patterned cross-section, corresponding to a pattern that is to be created in a target portion of the substrate; the terms "light valve" and "Spatial Light Modulator" (SLM) can also be used in this context. Generally, the said pattern will correspond to a particular functional layer in a device being created in the target portion, such as an integrated circuit or other device (see below). Examples of such patterning means include:

- A programmable mirror array. One example of such a device is a matrix-addressable surface having a viscoelastic control layer and a reflective surface. The basic principle behind such an apparatus is that (for example) addressed areas of the reflective surface reflect incident light as diffracted light, whereas unaddressed areas reflect incident light as undiffracted light. Using an appropriate filter, the said undiffracted light can be filtered out of the reflected beam, leaving only the diffracted light behind; in this manner, the beam becomes patterned according to the addressing pattern of the matrix-addressable surface. An alternative embodiment of a programmable mirror array employs a matrix arrangement of tiny mirrors, each of which can be individually tilted about an axis by applying a suitable localized electric field, or by employing piezoelectric actuation means. Once again, the mirrors are matrix-addressable, such that addressed mirrors will reflect an incoming radiation beam in a different direction to unaddressed mirrors; in this manner, the reflected beam is patterned according to the addressing pattern of the matrix-addressable mirrors. The required matrix addressing can be performed using suitable electronic means.

In both of the situations described hereabove, the programmable patterning means can comprise one or more programmable mirror arrays. More information on mirror arrays as here referred to can be gleaned, for example, from United States Patents US 5,296,891 and US 5,523,193, and PCT patent applications WO 98/38597 and WO 98/33096, which are incorporated herein by reference. In the case of a programmable mirror array, the said support structure may be embodied as a frame or table, for example, which may be fixed or movable as required.

- A programmable LCD array. An example of such a construction is given in United States Patent US 5,229,872, which is incorporated herein by reference. As above, the support structure in this case may be embodied as a frame or table, for example, which may be fixed or movable as required.

For purposes of simplicity, the rest of this text may, at certain locations, specifically direct itself to examples involving a mask and mask table; however, the general principles discussed in such instances should be seen in the broader context of the programmable patterning means as hereabove set forth.

Lithographic projection apparatus can be used, for example, in the manufacture of integrated circuits (ICs). In such a case, the programmable patterning means may generate a circuit pattern corresponding to an individual layer of the IC, and this pattern can be imaged onto a target portion (*e.g.* comprising one or more dies) on a substrate (silicon wafer) that has been coated with a layer of radiation-sensitive material (resist). In general, a single wafer will contain a whole network of adjacent target portions that are successively irradiated via the projection system, one at a time. In current apparatus, employing patterning by a mask on a mask table, a distinction can be made between two different types of machine. In one type of lithographic projection apparatus, each target portion is irradiated by exposing the entire mask pattern onto the target portion in one go; such an apparatus is commonly referred to as a wafer stepper. In an alternative apparatus —commonly referred to as a step-and-scan apparatus — each target portion is irradiated by progressively scanning the mask pattern under the projection beam in a given reference direction (the "scanning" direction) while synchronously scanning the substrate table parallel or anti-parallel to this direction; since, in general, the projection system will have a magnification factor M (generally < 1), the speed V at which the substrate table is scanned will be a factor M times that at which the mask table is scanned. More information with

regard to lithographic devices as here described can be gleaned, for example, from US 6,046,792, incorporated herein by reference.

In a manufacturing process using a lithographic projection apparatus, a pattern (e.g. in a mask) is imaged onto a substrate that is at least partially covered by a layer of radiation-sensitive material (resist). Prior to this imaging step, the substrate may undergo various procedures, such as priming, resist coating and a soft bake. After exposure, the substrate may be subjected to other procedures, such as a post-exposure bake (PEB), development, a hard bake and measurement/inspection of the imaged features. This array of procedures is used as a basis to pattern an individual layer of a device, e.g. an IC. Such a patterned layer may then undergo various processes such as etching, ion-implantation (doping), metallization, oxidation, chemo-mechanical polishing, etc., all intended to finish off an individual layer. If several layers are required, then the whole procedure, or a variant thereof, will have to be repeated for each new layer. Eventually, an array of devices will be present on the substrate (wafer). These devices are then separated from one another by a technique such as dicing or sawing, whence the individual devices can be mounted on a carrier, connected to pins, etc. Further information regarding such processes can be obtained, for example, from the book "Microchip Fabrication: A Practical Guide to Semiconductor Processing", Third Edition, by Peter van Zant, McGraw Hill Publishing Co., 1997, ISBN 0-07-067250-4, incorporated herein by reference.

For the sake of simplicity, the projection system may hereinafter be referred to as the "lens"; however, this term should be broadly interpreted as encompassing various types of projection system, including refractive optics, reflective optics, and catadioptric systems, for example. The radiation system may also include components operating according to any of these design types for directing, shaping or controlling the projection beam of radiation, and such components may also be referred to below, collectively or singularly, as a “lens”. Further, the lithographic apparatus may be of a type having two or more substrate tables (and/or two or more mask tables). In such “multiple stage” devices the additional tables may be used in parallel, or preparatory steps may be carried out on one or more tables while one or more other tables are being used for exposures. Dual stage lithographic apparatus are described, for example, in US 5,969,441 and WO 98/40791, incorporated herein by reference.

In presently known lithographic projection apparatus using programmable patterning means, the substrate table is scanned below the patterned projection beam. A

pattern is set on the programmable patterning means and is then exposed on the substrate during a pulse of the radiation system. In the interval before the next pulse of the radiation system, the substrate table moves the substrate to the position required to expose the next target portion of the substrate and the pattern on the programmable patterning means is updated. This process is repeated until a complete line on the substrate has been scanned whereupon a new line is started. During the small but finite time that the pulse of the radiation system lasts, the substrate table will consequently have moved a small but finite distance. Previously, this has not been a problem for lithographic projection apparatus using programmable patterning means because the size of the substrate movement during the pulse has been small relative to the size of the feature being exposed on the substrate. Therefore the error produced was not significant. However, as the features being produced on substrates become smaller, the error becomes more significant.

It is an object of the present invention to reduce the errors caused by the movement of the substrate during the pulse of the radiation system.

This and other objects are achieved according to the invention in a lithographic apparatus as specified in the opening paragraph, characterized in that the apparatus further comprises means for moving the patterned projection beam that is projected onto the substrate relative to the projection system during at least one pulse of the radiation system.

The means for moving the patterned projection beam allows the projection beam to remain more accurately aligned on the substrate, thus reducing any errors caused by the movement of the substrate relative to the projection system during the pulse of the radiation system.

Preferably the substrate is moved at a constant velocity relative to the projection system during a series of pulses of the radiation system and the intervals in between the pulses. The means for moving the patterned projection beam is then used to move the patterned projection beam in synchronism with the movement of the substrate for the duration of at least one pulse of the radiation system. Having the substrate moving at a constant velocity reduces the complexity of the substrate table and the positional drivers associated with it; but, by moving the patterned projection beam in synchronism with the movement of the substrate, the consequent errors are reduced.

The patterned projection beam may be moved in synchronism with the movement of the substrate during a plurality of pulses. This enables the images of the programmable patterning means to be projected onto the same part of the substrate a plurality of times.

This may be done, for example, if the intensity of the pulse of the patterned projection beam is not sufficient to produce a complete exposure on the substrate. Moving the patterned projection beam in synchronism with the substrate reduces the occurrence of overlay errors between subsequent exposures of the pattern on the substrate.

Successive patterns on the programmable patterning means that are exposed on the substrate by each pulse may be different. For example, corrections may be made in subsequent pulses to offset errors in a first pulse. Alternatively, changes in the pattern may be used to produce gray scale images for some of the features (for example, by only exposing those features for a proportion of the total number of pulses imaged onto a given part of the substrate).

Additionally or alternatively the intensity of the patterned projection beam, the illumination of the programmable patterning means or the pupil filtering may be changed for one of the pulses of the radiation system that are projected onto the same part of the substrate. This may be used, for example, to increase the number of gray scales that may be generated using the technique described in the preceding paragraph or may be used to optimise different exposures for features oriented in different directions.

The means for moving the patterned beam relative to the projection system may comprise a layer of electro-optical material through which the patterned projection beam passes. A control system may be provided to apply a control voltage across the electro-optical material, thereby changing the birefringence of the electro-optical material. The change in birefringence of the electro-optical material in response to changes in the control voltage moves the part of the patterned projection beam emitted from it that is polarized in a given direction. Therefore the patterned projection beam may be polarized such that all of the patterned projection beam is moved by changes in the birefringence of the electro-optical material.

Alternatively, the means for moving the patterned projection beam relative to the projection system may comprise a second layer of electro-optical material through which the patterned projection beam also passes. The second layer of electro-optical material is oriented such that by applying a control voltage to the second layer, changing its birefringence, the second layer moves that part of the patterned projection beam that is polarized in the opposite direction to that which is moved by the first layer. Consequently, the entirety of the patterned projection beam may be moved without the patterned projection beam needing to be polarized.

An alternative means for moving the patterned projection beam relative to the projection system comprises a reflective surface mounted such that the angle between the surface and the patterned projection beam incident on it can vary during the pulse of the radiation system. As the angle changes, so the position of the beam reflected from it is moved. A preferential means of embodying this system is a rotating prism with a polygonal cross-section. The edge faces form the reflective surface. As the prism rotates each face in turn reflects the patterned projection beam. Whilst the patterned projection beam is incident on each face, the angle of each face relative to the patterned projection beam changes. By careful tuning of the speed of rotation of the prism with respect to the pulse frequency of the radiation system and correct selection of the size of the prism, the required control of the movement of the patterned projection beam can be effected. An advantage of this system is that it does not require the radiation beam to be polarized and it can be effected in an apparatus that solely uses reflective components.

According to a further aspect of the invention there is provided:
a device manufacturing method comprising the steps of:

- providing a substrate that is at least partially covered by a layer of radiation sensitive material;
- providing a pulsed projection beam of radiation using a radiation system;
- using programmable patterning means to endow the projection beam with a pattern in its cross-section;
- projecting the patterned beam of radiation onto a target portion of the layer of radiation-sensitive material,
- moving the substrate relative to the projection system to target successive portions of the layer of radiation-sensitive material,

characterized by moving the patterned projection beam that is projected onto the substrate relative to the projection system during at least one pulse of the radiation system.

Although specific reference may be made in this text to the use of the apparatus according to the invention in the manufacture of ICs, it should be explicitly understood that such an apparatus has many other possible applications. For example, it may be employed in the manufacture of integrated optical systems, guidance and detection patterns for magnetic domain memories, liquid-crystal display panels, thin-film magnetic heads, etc. The skilled artisan will appreciate that, in the context of such alternative applications, any

use of the terms "reticle", "wafer" or "die" in this text should be considered as being replaced by the more general terms "mask", "substrate" and "target portion", respectively.

In the present document, the terms "radiation" and "beam" are used to encompass all types of electromagnetic radiation, including ultraviolet radiation (*e.g.* with a wavelength of 365, 248, 193, 157 or 126 nm) and EUV (extreme ultra-violet radiation, *e.g.* having a wavelength in the range 5-20 nm), as well as particle beams, such as ion beams or electron beams.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying schematic drawings in which:

Figure 1 depicts a lithographic projection apparatus according to an embodiment of the invention;

Figure 2 depicts a first embodiment of the means for moving the patterned projection beam according to the present invention;

Figure 3 depicts a second embodiment of the means for moving the patterned projection beam according to the present invention;

Figure 4 depicts a third embodiment of the means for moving the patterned projection beam according to the present invention; and

Figure 5 depicts a variant of the embodiment shown in Figure 4.

In the Figures, corresponding reference symbols indicate corresponding parts.

Embodiment 1

Figure 1 schematically depicts a lithographic projection apparatus according to a particular embodiment of the invention. The apparatus comprises:

- a radiation system Ex, IL, for supplying a projection beam PB of radiation (*e.g.* UV radiation), which in this particular case also comprises a radiation source LA;
- a first object table (mask table) MT provided with a mask holder for holding a programmable patterning means MA (*e.g.* an SLM), and connected to first positioning

means for accurately positioning the programmable patterning means with respect to item PL;

- a second object table (substrate table) WT provided with a substrate holder for holding a substrate W (*e.g.* a resist-coated silicon wafer), and connected to second positioning means for accurately positioning the substrate with respect to item PL;
- a projection system ("lens") PL (*e.g.* a refractive mirror group) for imaging an irradiated portion of the programmable patterning means MA onto a target portion C (*e.g.* comprising one or more dies) of the substrate W.

As here depicted, the apparatus is of a reflective type (*e.g.* has a reflective programmable patterning means). However, in general, it may also be of a transmissive type, for example (*e.g.* with a transmissive programmable patterning means). Alternatively, the apparatus may employ another kind of patterning means, such as a programmable LCD array of a type as referred to above.

The source LA (*e.g.* an excimer laser) produces a beam of radiation. This beam is fed into an illumination system (illuminator) IL, either directly or after having traversed conditioning means, such as a beam expander Ex, for example. The illuminator IL may comprise adjusting means AM for setting the outer and/or inner radial extent (commonly referred to as σ-outer and σ-inner, respectively) of the intensity distribution in the beam. In addition, it will generally comprise various other components, such as an integrator IN and a condenser CO. In this way, the beam PB impinging on the programmable patterning means MA has a desired uniformity and intensity distribution in its cross-section.

It should be noted with regard to Figure 1 that the source LA may be within the housing of the lithographic projection apparatus (as is often the case when the source LA is a mercury lamp, for example), but that it may also be remote from the lithographic projection apparatus, the radiation beam which it produces being led into the apparatus (e.g. with the aid of suitable directing mirrors); this latter scenario is often the case when the source LA is an excimer laser. The current invention and Claims encompass both of these scenarios.

The beam PB subsequently intercepts the programmable patterning means MA, which is held on a mask table MT. Having been reflected by the programmable patterning means MA, the beam PB passes through the lens PL, which focuses the beam PB onto a target portion C of the substrate W. With the aid of the second positioning means (and interferometric measuring means IF), the substrate table WT can be moved accurately, *e.g.*

so as to position different target portions C in the path of the beam PB. Similarly, the first positioning means can be used to accurately position the programmable patterning means MA with respect to the path of the beam PB, *e.g.* during a scan. The first positioning means may be omitted, in which case the position of the programmable patterning means relative to the beam PB will be fixed. In general, movement of the object tables MT, WT will be realized with the aid of a long-stroke module (course positioning) and a short-stroke module (fine positioning), which are not explicitly depicted in Figure 1. However, in the case of a wafer stepper (as opposed to a step-and-scan apparatus) the mask table MT may just be connected to a short stroke actuator, or may be fixed.

The depicted apparatus is used in the following manner:

In pulse mode, the mask table is kept essentially stationary and an entire image of the programmable patterning means is projected onto a target portion C of the substrate. The substrate table WT is moved with an essentially constant speed such that the projection beam PB is caused to scan a line across the substrate W. The pulses of the radiation system are timed such that successive target portions C that are exposed on the substrate are adjacent to one another. Consequently, once the projection beam has scanned an entire line of the substrate W the complete pattern for that line is exposed on the substrate. The process is repeated until the complete substrate has been exposed line by line.

Figure 2 shows, schematically, a means for shifting the patterned projection beam. As shown, the patterned projection beam 2 passes through a polarizing filter 3. The patterned projection beam then passes through a layer of electro-optical material 4. A voltage V applied to the electro-optical material 4 changes its birefringence as required. When no voltage is applied, the patterned projection beam follows the path denoted 5. When a voltage is applied to the electro-optical material 4 the patterned projection beam is shifted to the path denoted 6.

After the electro-optical material, the patterned projection beam may then be passed through a quarter wavelength plate 7, for example, to circularly-polarize the patterned projection beam if required. Alternatively the patterned projection beam could remain linearly polarized or could be de-polarized. The optical axis of the electro-optical material 4 is oriented such that the polarized projection beam is shifted by the birefringence of the electro-optical material 4. The shift S produced by applying a voltage to the electro-optical material 4 can be determined by the following equation:

$$S = d \cdot \sin\alpha \cdot \cos\alpha \cdot \left(\frac{1}{\sqrt{n_1^2 - \sin^2\alpha}} - \frac{1}{\sqrt{n_0^2 - \sin^2\alpha}} \right) \quad [1]$$

where d is the thickness of the layer of electro-optical material, α is the angle between the patterned projection beam and the surface of the electro-optical material, N_0 is the ratio of the refractive index of the environment in which the apparatus functions to the refractive index of the electro-optical material when no voltage is applied and n_1 is the corresponding ratio of the refractive indices when a given voltage has been applied to the electro-optical material. Consequently, as the voltage applied to the electro-optical material is changed, the shift S changes. By applying a gradually changing voltage, the patterned projection beam can be caused to gradually shift. By applying an appropriately shaped signal to the electro-optical material the patterned projection beam can be caused to scan in synchronism with the substrate as it moves during the short time of a pulse of the radiation system. Consequently, the errors in the placement of features on the substrate are reduced.

Although as here shown the patterned projection beam 2 is polarized by means of a polarizing filter 3, this need not be the case. In particular, the patterned projection beam 2 may already be polarized, for example, as a result of the programmable patterning means or because the radiation source inherently produces polarized radiation.

The electro-optical layer may be formed from any well-known electro-optical materials, such as ADP, AD*P, KDP and KD*P. In order to obtain the best response from the electro-optical material, it is preferably operated close to, but above, the Curie temperature of the material used. The Curie temperature is generally lower than the ambient temperature for the apparatus. The KDP for example has a Curie temperature of 123 K, KD*P has a Curie temperature variously reported as 213 or 222 K and ADP has a Curie temperature of 148 K. Consequently a temperature controlled cooling unit (not shown) may be provided to cool the electro-optical layer.

Embodiment 2

Figure 3 shows an alternative embodiment of the present invention. This embodiment is similar to the first embodiment and the description of corresponding features will not be repeated. In this embodiment, a second layer of electro-optical

material 8 is provided. The direction of the optical axis of the second layer 8 is perpendicular to the optical axis of the first layer. Consequently, when a voltage V is applied to the first layer 4, radiation in the patterned projection beam that is polarized in a first direction is shifted and when a voltage V′ is applied to the second layer 8, radiation that is polarized in a second, orthogonal, direction is shifted. Therefore, by simultaneously applying voltages V, V′ to both layers of electro-optical material 4, 8 the entire patterned projection beam 2 is shifted, without the need for it to be polarized.

The shift produced by the second layer 8 of electro-optical material can be determined using Equation 1 given above. Some calibration may be required to ensure that both polarizations of the radiation are shifted by the same amount. Slight differences in the thicknesses D, D′ of the two layers of electro-optical material 4, 8 can be compensated for by adjustments of either voltage V or voltage V′. It has been found that a 7kV voltage change across a layer of electro-optical material of 0.7 mm thickness produces a 50 nm shift.

Embodiment 3

Figure 4 shows an alternative embodiment of the present invention. In this case, the means for shifting the patterned projection means 2 is provided by a rotating prism 15, here shown in cross section that may be located in the back focal plane of the lithographic apparatus. The prism has a plurality of faces 16 that are reflective to the patterned projection beam 2. Figure 4 shows the situation at a first time point when the prism 15 is in a first position and at a second time point when the prism 15′ is in a second position. As the prism rotates the angle at which the patterned projection beam 2 is incident on the reflective face 16 of the prism changes. Correspondingly, the angle at which the patterned projection beam 5, 6 radiates from the reflective face 16 also changes. As shown, the difference in angles between the reflected patterned projection beam 5 at the first time point and the reflected patterned projection beam 6 at the second time point produces a shift S where the patterned projection beam is incident on the substrate. By careful timing of the rotation of the prism 15, the patterned projection beam 2 can be made to scan in synchronism with the moving substrate for the duration of a pulse of radiation. In the interval between pulses of radiation the prism 15 rotates to present a different face 16 at the start of the subsequent pulse of the radiation system.

Alternatively, a transparent rotating prism 25 may be used, as shown in Figure 5. In this case, the prism may be located in the imaging plane.

Errors caused by the movement of the substrate during a pulse of radiation are reduced by providing means to shift the patterned projection beam in synchronism with the movement of the substrate during a pulse of radiation. Alternative means of shifting the patterned projection beam may be within the scope of the invention.

Whilst specific embodiments of the invention have been described above, it will be appreciated that the invention may be practiced otherwise than as described. The description is not intended to limit the invention.

CLAIMS:

1. A lithographic projection apparatus comprising:

- a radiation system for providing a pulsed projection beam of radiation;
- programmable patterning means for patterning the projection beam according to a desired pattern;
- a substrate table for holding a substrate;
- a projection system for projecting the patterned beam onto a target portion of the substrate,
- means for moving the substrate relative to the projection system.

characterized in that the apparatus further comprises means for moving the patterned projection beam that is projected onto the substrate relative to the projection system during at least one pulse of the radiation system.

2. A lithographic projection apparatus according to claim 1, wherein the substrate is moved at a substantially constant velocity relative to the projection system during the course of a plurality of pulses of the radiation system and the intervals therebetween; and the patterned projection beam is moved in synchronism with the movement of the substrate for the duration of at least one pulse of the radiation system.

3. A lithographic projection apparatus according to claim 2, wherein the patterned projection beam is moved in synchronism with the movement of the substrate during a plurality of pulses of the radiation system such that the image of the programmable patterning means is projected onto substantially the same place on the substrate a plurality of times.

4. A lithographic projection apparatus according to claim 3, wherein the pattern provided to the programmable patterning means is changed between successive pulses of the radiation system that are projected onto substantially the same place on the substrate.

5. A lithographic projection apparatus according to claim 3 or 4, wherein at least one of the intensity of the patterned projection beam, the illumination of the programmable patterning means and the pupil filtering are changed for at least one of said pulses of the radiation system that are projected onto substantially the same place on the substrate.

6. A lithographic projection apparatus according to any one of the preceding claims, wherein the means for moving the patterned projection beam relative to the projection system comprises: a layer of electro-optical material through which the patterned projection beam passes and a control system for providing a control voltage across the electro-optical material; and where adjusting said control voltage changes the birefringence of the electro-optical material, moving at least a part of the patterned projection beam emitted from it.

7. A lithographic projection apparatus according to claim 6, wherein the patterned projection beam is polarized and the direction of the optical axis of the electro-optical material is oriented such that substantially all of the projection beam is moved.

8. A lithographic projection apparatus according to claim 6, wherein the means for moving the patterned projection beam relative to the projection system comprises a second layer of electro-optical material through which the patterned projection beam passes and to which the control system provides a control voltage to change its birefringence; and wherein the direction of the optical axis of the second layer of electro-optical material is substantially perpendicular to that of the first layer, such that changing the birefringence of both layers moves substantially all of the projection beam.

9. A lithographic projection apparatus according to any one of claims 1 to 5, wherein the means for moving the patterned projection beam relative to the substrate comprises: a reflective surface mounted such that the angle between the surface and the patterned projection beam incident upon it varies during said pulse of the radiation.

10. A lithographic projection apparatus according to any one of claims 1 to 5, wherein the means for moving the patterned projection beam relative to the substrate comprises: an element that is transmissive to the beam of radiation, mounted such that the angle between

the radiation beam and the surface on which it is incident varies during said pulse of radiation.

11. A lithographic projection apparatus according to claim 9 or 10, wherein said means for moving the patterned projection beam relative to the substrate comprises a rotating prism, the end faces of which are polygonal; and wherein at least one longitudinal face is the surface on which the patterned projection beam is incident during said pulse of the radiation system.

12. A device manufacturing method comprising the steps of:

- providing a substrate that is at least partially covered by a layer of radiation sensitive material;
- providing a pulsed projection beam of radiation using a radiation system;
- using programmable patterning means to endow the projection beam with a pattern in its cross-section;
- projecting the patterned beam of radiation onto a target portion of the layer of radiation-sensitive material,
- moving the substrate relative to the projection system to target successive portions of the layer of radiation-sensitive material,

characterized by moving the patterned projection beam that is projected onto the substrate relative to the projection system during at least one pulse of the radiation system.

ABSTRACT

Lithographic Apparatus and Device Manufacturing Method.

Means for compensating for the movement of a substrate in a lithographic apparatus during a pulse of radiation by providing a means of moving the patterned projection beam incident on the substrate in synchronism with the substrate.

Fig. 2

Fig. 1

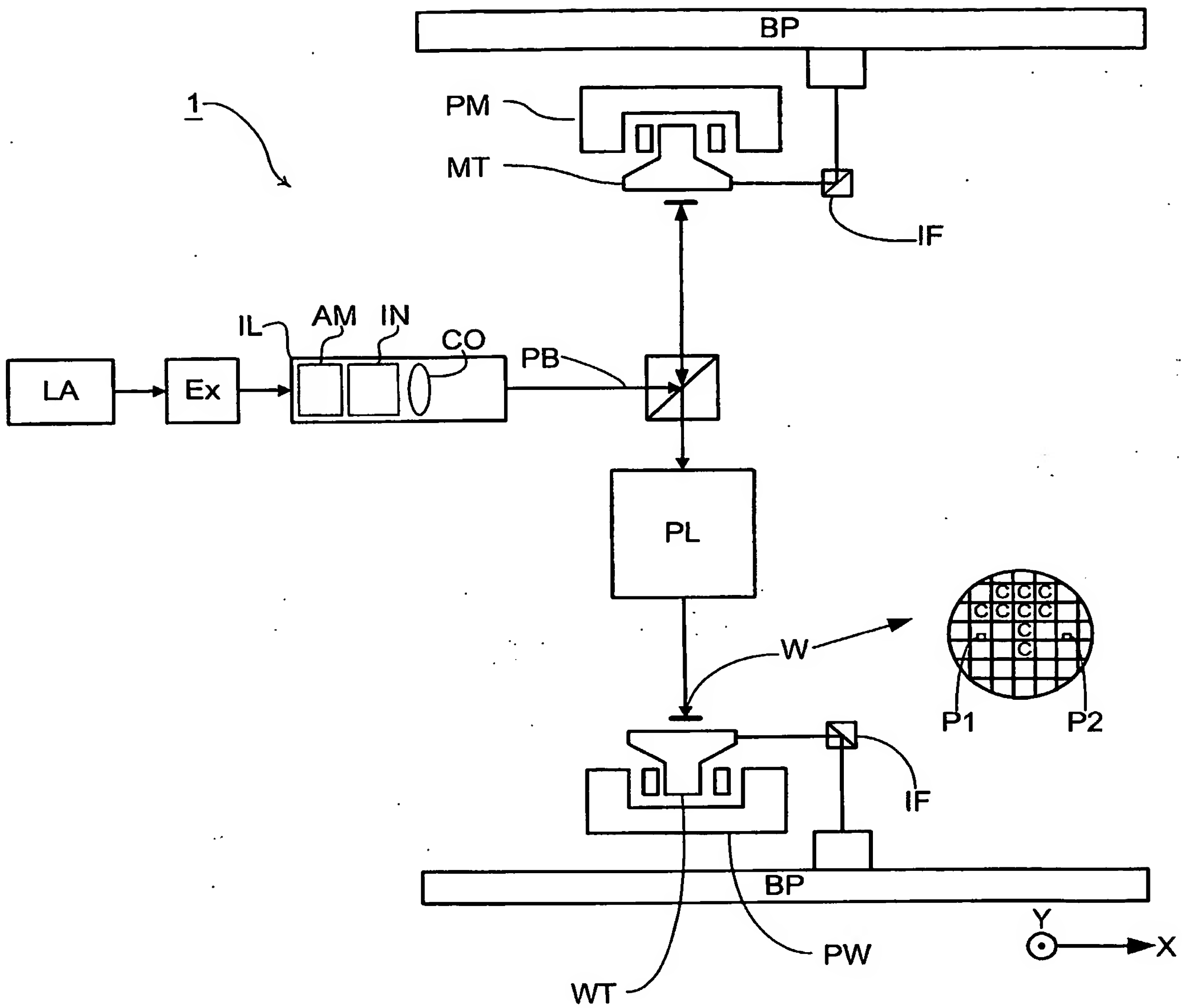

Fig. 2

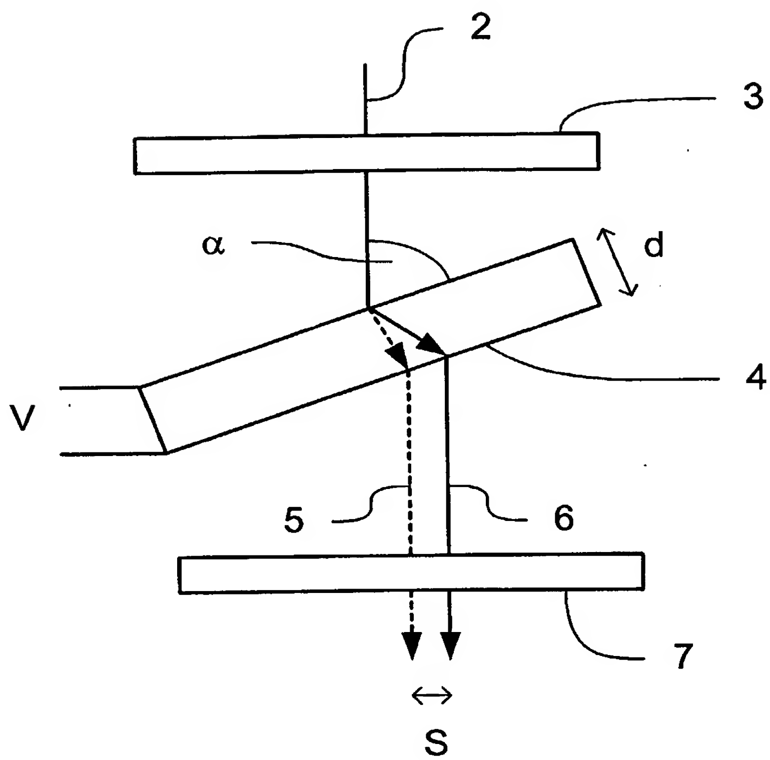

Fig. 3

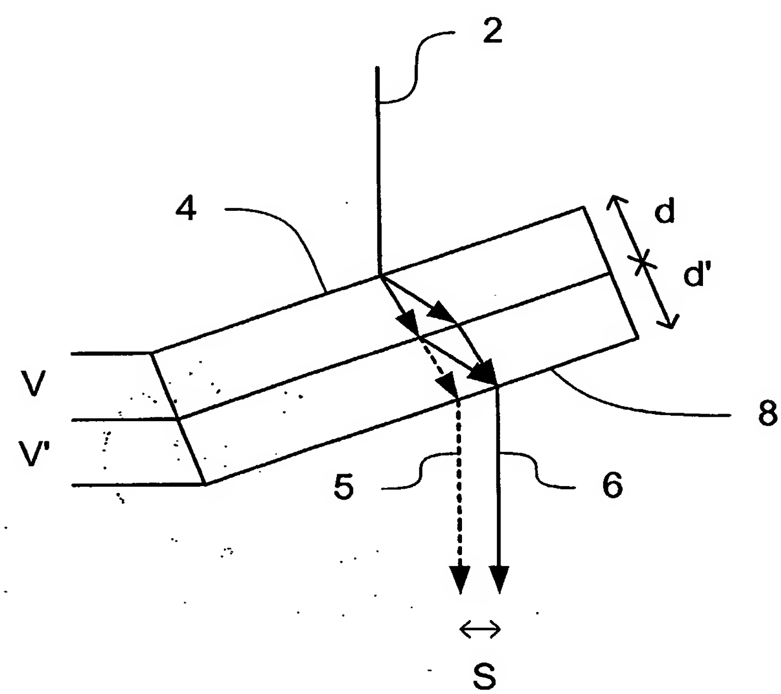

Fig. 4

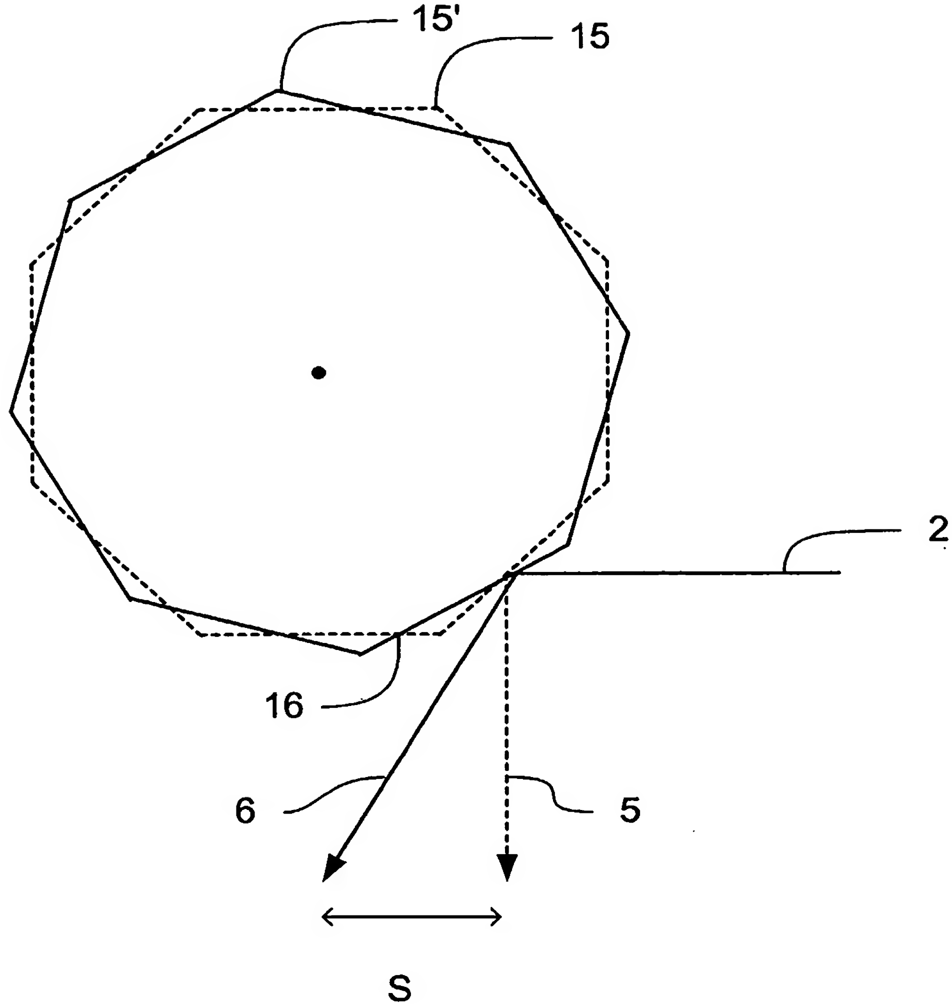

Fig. 5